

## **CLOCK GENERATING DEVICE**

### **BACKGROUND OF THE INVENTION**

This invention relates to a clock generating device, a circuit board, an image forming apparatus, and the method of generating a clock, and in particular, to the control of the period or phase of a clock pulse at an arbitrary timing.

A clock is necessary for the circuit operation in various kinds of digital circuits. This clock is generated by a clock generating circuit of any one of various types.

In a clock generating circuit which has been heretofore in practice, the period (frequency) of a clock is constant, and the positions of the leading edge and the trailing edge are in a fixed state.

Further, for a device which does not make the period of a clock constant, but makes it vary with time (to make frequency modulation), an IC for frequency-modulating a clock by a PLL circuit has been put on the market.

Further, it is possible to vary the frequency (period) of a clock subtly by using a VCXO (crystal oscillator of an external voltage control type), a DDS (digital direct synthesizer), or the like.

However, in the case where the period or frequency is varied by such an IC for frequency-modulating a clock as described in the above, namely a VCXO or a DDS, it operates with the period or frequency varied or not varied from the beginning to the end, and it has not such a function as to vary the period or frequency for a certain time only.

Further, it may be possible to mount a control circuit to change a frequency or a phase of clock pulses for a certain time period as an external device to a clock generating circuit. However, in the thus structured circuit, from the point of the response speed, it has been difficult to change the frequency or the phase with the high accuracy within a very short time period. Also, it has been almost impossible to make the above circuit in a single chip integral circuit.

This invention has been made in order to solve the above-mentioned problem, and it is a first object of the invention to provide a clock generating device, a base board, an image forming apparatus and a clock generating method,

wherein it is possible to change a frequency or a phase of clock pulses with the high accuracy at an optional time.

Further, this invention relates to a clock generating device to generate dithering clocks on the condition that frequency band is spread, a circuit board, an image forming apparatus, and a method of generating clocks.

From the conventional clock generating apparatus and various types of apparatus which receives clocks, higher harmonic wave having a frequency obtained by multiplying a clock frequency with an integer is emitted as radiated electromagnetic noise toward the outside of the apparatus.

Since the radiated electromagnetic noise causes problems, various measures to counter EMI (Electro-Magnetic Interference) are proposed in order to reduce the e

Therefore, there has been developed the technique to lower the level at the peak portion by spreading the frequency band of the emitted electromagnetic wave by subjecting clocks to frequency modulation (clock dithering).

As a device to realize the technique, there has been sold at a market an IC to output dithering clock by subjecting inputted clock to frequency modulation with a PLL circuit.

In the marketed IC to output the inputted clock as dithering clock by subjecting the inputted clock to frequency

modulation with the PLL circuit, there may be a problem that normal action against discontinuous clock is not guaranteed or setting-up takes a time due to its internal feed-back loop.

Further, IC to output the dithering clock is a single body device and PLL is basically an analog circuit. Therefore, there may be problem that it may be impossible to structure them integrally with other digital circuits.

A second object of the present invention is to provide a clock generating apparatus and a clock generating method capable of being formed integrally with the other digital circuits while reducing the level of radiated electromagnetic noise.

Further, the second object of the present invention is to provide a base board and an image forming apparatus provided with a clock generating apparatus capable of being formed integrally with the other digital circuits while reducing the level of radiated electromagnetic noise.

#### **SUMMARY OF THE INVENTION**

The first object can be attained by any one of the following structures.

(1) A clock generating device comprising a clock generating section for generating a plurality of clocks

having different phases respectively, and a selecting section for selecting some one out of said plurality of clocks to output it and switching over the clock to a clock having a different phase or period to output it within a specified time of the clock to be outputted.

(2) A clock generating device comprising a clock generating section for generating a plurality of clocks having different phases respectively, a selecting section for selecting some one out of said plurality of clocks to output it, and a switching control section for judging if a clock having a different phase or period is to be selected within a specified time of the clock to be outputted from said selecting section.

(3) A clock generating device comprising a clock generating section for generating a plurality of clocks having different phases respectively, a selecting section for selecting some one out of said plurality of clocks on the basis of a selection signal to output it, and a switching control section for outputting a selection signal for selecting a clock having a different phase or period to said selecting section within a specified time of the clock to be outputted from said selecting section.

(4) A clock generating device as set forth in the paragraph (3), wherein the aforesaid switching control

section generates a selection signal indicating which one is to be selected out of the plural clocks on the basis of output clock information set beforehand and outputs it to said selecting section.

(5) A clock generating device as set forth in the paragraph (4), wherein the aforesaid output clock information is memorized beforehand in a memory portion or is set by an operation circuit.

(6) A clock generating device as set forth in any one of the paragraphs (1) to (5) which is made up of an integrated circuit.

(7) A clock generating device as set forth in the paragraph (6) which is made up of a digital circuit.

(8) A circuit board provided with a clock generating device as set forth in any one of the above paragraphs (1) to (7).

(9) An image forming apparatus in which a clock outputted from a clock generating device as set forth in any one of the above paragraphs (1) to (7) is used, and in a specified area of an image, a clock having a different phase or period from that of a clock used in other area.

(10) The method of generating a clock comprising the steps of generating a plurality of clocks having different phases respectively, selecting some one out of said plurality

of clocks to output, and switching over from a clock to a clock having a different phase or period within a specified time of the clock to be outputted.

Further, the second object can be attained by any one of the following structures.

(11) A clock generating apparatus is characterized by comprising:

a delay chain section in which delay elements are connected in the form of a chain in order to produce a delay clock delayed from a reference clock;

a synchronizing signal detecting section to select plural delay clocks synchronizing with a leading reference signal from the delay chain section and to guide synchronizing information corresponding to the delay stages of one cycle from the information;

a selecting section to a synchronizing clock synchronizing with the reference clock from the delay chain section by referencing the synchronizing clock guided in the synchronizing signal detecting section;

a switching control section to disperse time intervals of the clock signals by conducting selecting the synchronizing clock in the selecting section and selecting delay clock from the delay chain section in the way to add an optional time alternatively for each clock.

(12) A clock generating apparatus is characterized by comprising:

a delay chain section in which delay elements are connected in the form of a chain in order to produce a delay clock delayed from a reference clock;

a synchronizing signal detecting section to select plural delay clocks synchronizing with a leading reference signal from the delay chain section and to guide synchronizing information corresponding to the delay stages of one cycle from the information;

a selecting section to a synchronizing clock synchronizing with the reference clock from the delay chain section by referencing the synchronizing clock guided in the synchronizing signal detecting section;

a switching control section to disperse time intervals of the clock signals by conducting selecting the synchronizing clock in the selecting section and selecting delay clock from the delay chain section in the way to subtract an optional time alternatively for each clock.

(13) A clock generating apparatus is characterized by comprising:

a delay chain section in which delay elements are connected in the form of a chain in order to produce a delay clock delayed from a reference clock;



a synchronizing signal detecting section to select plural delay clocks synchronizing with a leading reference signal from the delay chain section and to guide synchronizing information corresponding to the delay stages of one cycle from the information;

a selecting section to a synchronizing clock synchronizing with the reference clock from the delay chain section by referencing the synchronizing clock guided in the synchronizing signal detecting section;

a switching control section to disperse time intervals of the clock signals by conducting selecting the synchronizing clock in the selecting section and selecting delay clock from the delay chain section in the way to add an optional time alternatively for each optional clock.

(14) A clock generating apparatus is characterized by comprising:

a delay chain section in which delay elements are connected in the form of a chain in order to produce a delay clock delayed from a reference clock;

a synchronizing signal detecting section to select plural delay clocks synchronizing with a leading reference signal from the delay chain section and to guide synchronizing information corresponding to the delay stages of one cycle from the information;

a selecting section to a synchronizing clock synchronizing with the reference clock from the delay chain section by referencing the synchronizing clock guided in the synchronizing signal detecting section;

a switching control section to disperse time intervals of the clock signals by conducting selecting the synchronizing clock in the selecting section and selecting delay clock from the delay chain section in the way to subtract an optional time alternatively for each optional clock.

(15) A clock generating apparatus is characterized by comprising:

a delay chain section in which delay elements are connected in the form of a chain in order to produce a delay clock delayed from a reference clock;

a synchronizing signal detecting section to select plural delay clocks synchronizing with a leading reference signal from the delay chain section and to guide synchronizing information corresponding to the delay stages of one cycle from the information;

a selecting section to a synchronizing clock synchronizing with the reference clock from the delay chain section by referencing the synchronizing clock guided in the synchronizing signal detecting section;

a switching control section to disperse time intervals of the clock signals by conducting selecting the synchronizing clock in the selecting section, selecting delay clock from the delay chain section in the way to add an optional time and selecting delay clock from the delay chain section in the way to subtract an optional time alternatively for each clock.

(16) A clock generating apparatus of the invention described in claim 6 is characterized by comprising:

a delay chain section in which delay elements are connected in the form of a chain in order to produce a delay clock delayed from a reference clock;

a synchronizing signal detecting section to select plural delay clocks synchronizing with a leading reference signal from the delay chain section and to guide synchronizing information corresponding to the delay stages of one cycle from the information;

a selecting section to a synchronizing clock synchronizing with the reference clock from the delay chain section by referencing the synchronizing clock guided in the synchronizing signal detecting section;

a switching control section to disperse time intervals of the clock signals by conducting selecting the synchronizing clock in the selecting section, selecting delay

clock from the delay chain section in the way to add an optional time and selecting delay clock from the delay chain section in the way to subtract an optional time alternatively for each optional clock.

(17) The clock generating apparatus is characterized in that in (11) to (16), each of the sections is structured by an integral circuit.

(18) The clock generating apparatus is characterized in that in (11) to (16), each of the sections is structured by a digital circuit.

(19) The clock generating apparatus is characterized in that in (11) to (16), the switching control section is controlled by CPU.

(20) A base board is characterized by being provided with the clock generating apparatus described in one of (11) to (19).

(21) An image forming apparatus is characterized by being controlled with the use of clocks outputted from the clock generating apparatus described in one of (11) to (19).

(22) A clock generating method is characterized by comprising:

producing a delay clock by delaying a reference clock with delay elements connected in the form of a chain;

guiding synchronizing information corresponding to the delay stages of one cycle from the information by selecting plural delay clocks synchronizing with a leading reference signal from the delay chain section;

conducting a first selection to select the synchronizing clock synchronizing with a reference clock from the delay clocks by referencing the synchronizing information and a second selection to select delay clock in the way to add an optional time for the synchronizing clock alternatively for each clock.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a structural drawing showing the overall electrical structure of a clock generating device of an example of the embodiment of this invention to attain the first object;

Figs. 2(a) to 2(n) are time charts for explaining the operation of a clock generating device of an example of the embodiment of this invention;

Fig. 3 is a structural drawing showing the electrical structure of the main part of a clock generating device of an example of the embodiment of this invention;

Figs. 4(a) and 4(b) are illustrations for explaining the operation of a clock generating device of an example of the embodiment of this invention;

Fig. 5 is a structural drawing showing the structure of the optical section of an image forming apparatus to which a clock generating circuit of an example of the embodiment of this invention is applied;

Fig. 6 is an illustrative drawing showing how a deviation is detected in an example of the embodiment of this invention;

Figs. 7(a) to 7(g) are time charts for explaining the operation of a clock generating device of an example of the embodiment of this invention;

Figs. 8(a) and 8(b) are time charts for explaining the operation of a clock generating device of an example of the embodiment of this invention;

Figs. 9(a) to 9(e) are time charts for explaining the operation of a clock generating device of an example of the embodiment of this invention;

Figs. 10(a) to 10(j) are time charts for explaining the operation of a clock generating device of an example of the embodiment of this invention;

Figs. 11(a) and 11(b) are drawings showing the modulation profile of a clock generating device; and

Fig. 12 is a characteristic chart showing the frequency band of a dithering clock generated by a clock generating device of an example of the embodiment of this invention.

Fig. 13 is a drawing showing the overall electrical structure of a clock generating device of an example of the embodiment of this invention to attain the second object;

Fig. 14 is a drawing showing the electrical structure of the main part of a clock generating device of an example of the embodiment of this invention;

Fig. 15 is a drawing showing the cross-sectional structure of an image forming apparatus to which a clock generating device of this invention is applied;

Fig. 16 is a block diagram showing the outline of the structure of the control system of an image forming apparatus according to the embodiment of this invention;

Fig. 17 is a drawing showing the modulation profile of a clock generating device;

Fig. 18 is a block diagram showing the outline of the structure of the control system of an image forming apparatus according to the embodiment of this invention; and

Fig. 19 is a block diagram showing the outline of the structure of the control system of an image forming apparatus according to the embodiment of this invention.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following, by referring to the drawings, it will be explained in detail, an example of the embodiment of an image forming apparatus and a clock generating device of this invention to attain the first object.

#### (OVERALL STRUCTURE OF A CLOCK GENERATING DEVICE)

In the following, an example of the embodiment of a clock generating device of this invention will be explained in detail.

In this Fig. 1, the CPU 401 operates as a control means for controlling the whole clock generating device. Moreover, this CPU 401 makes up a means for judging which clock is to be selected within a specified time of the clock.

The basic clock generating section 410 generates a clock which is made basic (a basic clock: Fig. 1(1)), and supplies it to various sections.

The delay chain section 420 as a clock generating section is a group of delay elements making up the clock generating section in the claims of this invention for obtaining a plurality of delayed clocks (the plural clocks: refer to Fig. 1(2) and Fig. 2) having phases a little different from one another respectively by delaying the input signal (the basic clock from the basic clock generating section 410).



In the above, it is desirable that the delay chain section 420 has a structure such that the delay elements are connected in cascade like a chain to make a number of stages capable of generating the delayed clocks having phases a little different from one another respectively over a time period of two periods of the basic clock.

Further, in this embodiment, the delayed clocks are generated by using delay elements, but it is also appropriate to provide a clock generating section capable of generating a plurality of clocks having different phases respectively without using delay elements.

Further, the basic clock generating section 410 may be comprised in each of the clock generating devices, or it is also possible to distribute a basic clock to each of the clock generating devices or to each of the circuit boards from the single basic clock generating section 410.

The synchronized signal detecting section 430 is a synchronism detecting means for detecting the number of the stage (synchronizing point) of the delayed clock which is synchronized with the basic clock (the leading edge position of the desired input signal) among the plural clocks (Fig. 1(2)), and outputs the synchronization information (Fig. 1(3)). In addition, this synchronization information can be also called the state of phase difference, and this state of

phase difference includes the synchronizing point and the state of the phase difference itself.

In the above, it is desirable that the synchronized signal detecting section 430 can output the first synchronizing point information V1st for the one synchronized with the basic clock first out of the plural clocks (Fig. 1(2)), the second synchronizing point information V2nd for the one synchronized with the basic clock second, and the number of stages of the delay Vprd between them. In the example shown in Fig. 2, the first synchronizing point information V1st = 20, the second synchronizing point information V2nd = 50, and the number of stages of the delay Vprd = 30.

The switching control section 440 outputs the selecting stage number information ("selection signal" in the claims: Fig. 1(7)), that is, the information of which phase the clock is to be selected out of the plural clocks (Fig. 1(2)), in order to produce the rise and fall of the clock at desired timings on the basis of the basic clock (Fig. 1(1)) from the basic clock generating section 410, the synchronizing point information (Fig. 1(3)) from the synchronized signal detecting section 430, the shift information ("output clock information" in the claims: Fig. 1(4)) from the CPU 401, and

the area information (Fig. 1(6)) from the control counter 470.

Further, the control counter 470 receives the area data (Fig. 1(5): starting area data and ending area data), and generates the area information (Fig. 1(6)) indicating the area for which switching over from a clock to a clock having a different phase or period is to be done.

Moreover, the structure of the above-mentioned switching control section 440 is made up as shown in Fig. 3. That is, it is composed of the switching counter portion 441 for generating counter data through receiving the basic clock and the valid timing signals (H\_VALID and V\_VALID) and the selecting signal operating portion 442 for generating the selecting stage number information (Fsync) through receiving the above-mentioned counter data, the shift information from the CPU 401, and the synchronizing point information (V1st, V2nd, and Vprd) from the synchronized signal detecting section 430.

The selecting section 450 is a selection means which receives the selecting stage number information (Fig. 1(7)) from the switching control section 440, and selects or composes a clock out of plural clocks within a specified time so as to obtain a state in which a clock having a phase or

period different from a usual one is to be outputted, to output it as a dithering clock (Fig. 1(8)).

In addition, in this specification, it is called "clock dithering" to obtain the same effect as the frequency modulation by varying the frequency of a clock through varying the timings of the rise and fall, the period, frequency, or phase of a clock to be outputted. Further, a clock obtained by this clock dithering is to be called a "dithering clock".

(OUTLINE OF THE OPERATION OF A CLOCK GENERATING DEVICE)

According to a clock generating device of this example of the embodiment, it is possible to make a state in which a clock is switched over to a clock having a phase or period different from a usual one to be outputted within a specified time by the area information (Fig. 1(6)) from the control counter 470.

For example, Fig. 4 schematically shows an image area formed by an image forming apparatus, and further, it schematically shows the sorting of clocks in the image area.

(1) As shown in Fig. 4(a), in the area A as the major part, a usual clock is generated, and in the area B, a clock which is different in any one of the phase, period, and frequency from a usual clock is generated. For example, in the case where a character image is present in the area A,

and a photographic image is present in the area B, it can be thought of a way of use in which a clock having a higher frequency is used in the area B in order to raise the resolution of the area.

(2) As shown in Fig. 4(b), in the area A as the smaller part, a usual clock is generated and in the area B as the larger part, a clock which is different in any one of the phase, period, and frequency from a usual clock is generated. For example, in the case where a photographic image is present in the area A and a character image is present in the area B, it can be thought of a way of use in which the image is formed by a usual clock in the area A, and for the character image in the area B, as a countermeasure against EMI, a dithering clock having a phase and frequency varying with time every moment. In this case, it is prevented that the photographic image is disturbed by the dithering clock, while for the image as a whole a countermeasure against EMI can be taken by the dithering clock.

Further, in the above (1) and (2), the position, number, and size of the areas for which a usual clock is switched over to a dithering clock are not limited to those shown in this embodiment.

(BASIC OPERATION OF A CLOCK GENERATING DEVICE (1): USUAL CLOCK)

#### OPTICAL STRUCTURE:

The structure of the optical writing section in an image forming apparatus to which a clock generating device of this example of the embodiment can be applied is such one as shown in Fig. 5. That is, on the basis of a signal generated in the circuit section 480, the LD 470 emits light. Then, after the laser beam from the LD 470 passes through the collimator lens 491 and the cylindrical lens 492, it is deflected for scanning by the polygonal mirror 493, and passes through the f $\theta$  lens 494 and the cylindrical lens 495, to write an image on the image carrying member 1. Further, a part of the laser beam deflected by the polygonal mirror for scanning is conducted to the index sensor 412, and its timing is detected.

#### PRINCIPLE OF DETECTING A DEVIATION:

Now, by referring to Fig. 6, it will be explained simply how a deviation is detected. An image having a specified pattern (in this embodiment, an image of a pattern having a shape of 'katakana' "fu", a character in Japanese alphabet having a form made up of a horizontal line and an oblique line meeting at their ends to make an acute angle as shown in Fig. 6) is formed at the front side in the main scanning direction on the image carrying member by the exposure unit of an image forming apparatus. Although the

pattern shown by the solid line is formed on the image carrying member, the basic pattern shown by the dotted line is supposed to be formed originally.

In this drawing, owing to the aberration of the exposure unit and the various optical elements etc., a deviation of  $dx$  is produced in the main scanning direction. In this case, by carrying out reading by the index sensor 412 which is disposed at a position capable of reading the pattern (refer to Fig. 5), as the image carrying member is being moved in the sub-scanning direction, the reading time corresponding to the distance  $Y'$  from the horizontal line to the oblique line of the "フ"-shaped pattern can be obtained.

The distance  $dy$  also can be obtained from the moving velocity of the image carrying member in the sub-scanning direction and the difference between the reading times of the horizontal line and the oblique line. Next, assuming that the angle made by the horizontal line and the oblique line is  $\theta$ , the deviation  $dx$  in the main scanning direction can be obtained from the expression  $dx = dy/\tan\theta$ .

Accordingly, for each of the colors Y, M, C, and K, by carrying out the formation of such a specified pattern and the reading of it, it is possible to detect the state of image deviation at the front end in the main scanning

direction (the information on the deviation at the image front end).

Further, by forming the "fu"-shaped patterns having the same shape respectively at the front end side and the tail end side in the main scanning direction at the same sub-scanning position and measuring the distance between them, it is possible to detect the state of deviation concerning the expansion and contraction of an image in the main scanning direction (the information on frequency deviation).

Further, after the CPU 401 has carried out the above-mentioned detecting processes, the output clock information (Fig. 1(4)) is generated from the information on the deviation at the image front end and the information on frequency deviation, and it is supplied to the switching control section 440.

#### GENERATION OF A USUAL CLOCK:

First, by referring to the time chart in Fig. 7, for a certain color in the image forming apparatus, it will be explained an operation to make an adjustment such that, by referring to the output clock information (Fig. 1(4)), delayed clocks having different phases respectively are successively shifted for each pulse to make the number of the pulses become a specified number, while the time for



generating this specified number of pulses is made to be a specified time (an operation to generate a usual clock).

The output clock information detected by the formation of the specified pattern and the reading of it described in Fig. 6 (The deviation information indicating the deviation ER, the clock period information on the clock period TC which can be obtained from the frequency of the basic clock, and the information on the number of pixels in one line indicating the number of pixels PH to be formed in the main scanning direction) is given to the correction value operating means in the switching control section 440 from the CPU 401. Further, from the first synchronizing point information V1st and the second synchronizing point information V2nd from the synchronized signal detecting section 430, the number of stages of the delay Vprd is obtained.

Now, the correction value operating means in the switching control section 440 calculates the correction count value (count load data) CC corresponding to the correction value on the basis of the expression shown below:

$$CC = PH \times (Vprd/TC)/ER \quad \text{----- (1).}$$

This correction count value CC is for carrying out the switchover by the switching counter portion 441 in the switching control section 440 counting down the number of

pulses. Accordingly, the larger the correction value becomes, the smaller becomes the correction count value CC for switching over.

Further, by referring to the rise of the index signal from the index sensor 412, the synchronized signal detecting section 430 obtains it as the synchronizing point information, the stage number of the delay chain section 420 at which the delayed clock synchronized with the rise of this index signal is obtained.

In this embodiment, it is assumed that 20 for the first synchronizing point information V1st and 50 for the second synchronizing point information V2nd are obtained. Then, in this case, the above-mentioned number of the stages of the delay Vprd is 30.

Now, by the scanning of the laser beam of the exposure unit, the index signal is generated at the timing when the index sensor has detected the laser beam (Fig. 7(a)(1)). After this, H\_VALID indicating the effective area in the horizontal direction becomes active.

Then, the switching counter portion 441 in the switching control section 440 continues repeatedly to count down the above-mentioned correction count value CC in accordance with the basic clock. Thus, every time when the count value becomes 0 by the counting down, the count data is

given to the selecting signal operating portion 442 in the switching control section 440 as an interruption (Fig. 7(d) to (f)).

Further, the CPU 401 gives the deviation direction information to the selecting signal operating portion in the switching control section 440; it gives "- correction" information for carrying out the contraction correction for the deviation expanded in the main scanning direction, and "+ correction" information for carrying out the expansion correction for the deviation contracted in the main scanning direction. Here, the case of "- correction" is taken for instance.

It is assumed that, by the formation of the above-mentioned specified pattern and the measurement of it, the deviation information ER and the deviation direction information have already been obtained. Here, it is assumed that  $ER = 6 \text{ ns}$ , and the deviation direction information = "- correction", that is, it indicates that correction should be done to contract the image because it is expanded.

First, by referring to the rise of the index signal from the index sensor 412, the synchronized signal detecting section 430 obtains the first synchronizing point information V1st and the second synchronizing point information V2nd.

The above-mentioned first synchronizing point information V1st indicates the stage number of the delay element in the delay chain section 420 synchronized with the rise of the index signal, and the above-mentioned second synchronizing point information V2nd indicates the stage number of the delay element in the delay chain section 420 delayed by one period of the basic clock from the above-mentioned first synchronizing point information V1st.

Here, it is assumed that  $V1st = 20$  and  $V2nd = 50$ . In addition, this situation is the state shown in Fig. 2. In this drawing, it is shown the state in which the DL 20 at the 20th stage (Fig. 2(c)) and the DL 50 at the 50th stage (Fig. 2(m)) delayed by one period of the clock from the DL 20 are synchronized with the rise of the index signal (Fig. 2(a)).

Next, from the above-mentioned first synchronizing point information V1st and the above-mentioned second synchronizing point information V2nd, the number of stages of the delay Vprd is obtained. Here, the above-mentioned number of the stages of the delay Vprd indicates how many stages of the delay element one period of the basic clock corresponds to. In this example of the embodiment, from the expression  $Vprd = V2nd - V1st$ ,  $Vprd = 30$  is obtained.

Further, the delay time of the delay element for one stage DT is obtained from the above-mentioned Vprd and the

period of the basic clock. For example, in the case where the period of the basic clock TC is 30 ns, because  $V_{prd} = 30$ , from the expression  $DT = TC/V_{prd}$ ,  $DT = 1$  ns is obtained.

Further, the number of stages of switching NC, which indicates by how many stages of delay element in the delay chain section 420 the phase is to be deviated finally in order to obtain a proper image signal, is obtained from the deviation information ER, the deviation direction information, and the delay time DT. In this case, from  $ER = 6$  ns, the deviation direction information is "- correction", and  $DT = 1$  ns, the number of stages of switching  $NC = -6$ .

In order to obtain a proper image signal from the above-mentioned number of stages of switching, the stage number of the delay element should be increased by six stages. That is, in synchronism with the rise of the index signal, the clock from the delay element of the 50th stage is adopted first, and after that, in synchronism with the selecting stage number information, the signals of the 49th, 48th, 47th, 46th, and 45th stage are successively adopted in such a way that the former one is substituted by the latter one, and finally, the clock from the 44th stage should be adopted.

Further, in the case where the number of stages of switching NC is larger than the number of stages of the delay

Vprd, it is appropriate to circulate the selecting stage number information. In the above-mentioned example, in the "- correction" in the case where  $V1st = 20$ ,  $V2nd = 50$ , and the number of stages of the delay is 30, when the selecting stage number information becomes successively 50, 49, ---, 21, 20, the selecting stage number 20 and the selecting stage number 50 are of the same phase; therefore, next the selecting stage number information should be 49, 48, ---. That is, it becomes 50, 49, ---, 21, 20 (= 50), 49, 48, ---. Further, in the "+ correction", it is appropriate to circulate the selecting stage number information in the same way.

Further, in the case where the "- correction" by three stages a time is done in such a way that the selecting stage number is successively made 50, 47, 43, ---, 22, 19, it becomes under  $V1st = 20$ ; then, next to 19, it should be made  $50 - (20 - 19) - 3 = 46$ . That is, by making the circulation begin with a value obtained from the subtraction: 50 minus a value consisting of the remainder from the synchronizing point ( $20 - 19 = 1$  in the above example) and the amount of one correction (3 in the above example), it can be done without any problem.

In the selecting section 450 having received such a selecting stage number information, out of the plural clocks (Fig. 1(2)) from the delay chain section 420, the clocks from the 50th stage, 49th stage, 48th stage, 47th stage, ---, are successively selected in place of the former one and the selected one is outputted as a dot clock (usual clock) (Fig. 7(g)).

Further, in the case of an image forming apparatus, by using a dot clock generated in this way, it generates an image signal, and forms an image by applying a laser beam from the LD 470 in accordance with this image processing.

(BASIC OPERATION OF A CLOCK GENERATING DEVICE (2):

DITHERING CLOCK)

OUTLINE OF A DITHERING CLOCK:

In this clock generating device, as shown in the above-mentioned Fig. 4, it is possible to make a state in which a clock is switched over within a specified time to a clock having a different phase or period (dithering clock) from the above-mentioned usual clock, and the dithering clock is outputted.

That is, it is possible for a clock generating device shown in the above-mentioned Fig. 1, within a specified time of a clock to be outputted,

(1) to select a clock having a phase or period different from a usual clock, to output it, or

(2) to select at least two clocks having different phases respectively out of plural clocks, to output a composite clock.

Further, for the above-mentioned selection and composing, the following modes such as (a) to (j) can be thought of.

(a) a mode in which some one out of the plural clocks is selected to be outputted, and it is switched over to a different clock and outputted within a specified time of the clock to be outputted.

(b) a mode in which at least two clocks having different phases from one another among the plural clocks are combined and outputted as a composite clock within a specified time of the clock to be outputted.

(c) a mode in which, at the time of selecting and outputting some one out of the plural clocks, it is carried out within a specified time of the clock to be outputted, a judgement which clock is to be selected.

(d) a mode in which some one is selected and outputted out of the plural clocks on the basis of a selection signal, and different clocks are selected for the leading edge and



for the trailing edge within one period of the clock to be outputted.

(e) a mode in which, at the time of selecting and outputting some one out of the plural clocks on the basis of a selection signal, the selection signal is outputted to the selecting section within a specified time of the clock to be outputted.

(f) a mode in which, on the basis of the output clock information set beforehand, a selection signal indicating which clock is to be selected out of the plural clocks is generated and outputted to the selecting section.

(g) a mode in which, on the basis of the output clock information set beforehand and the state of phase difference detected by the synchronized signal detecting section, a selection signal indicating which clock is to be selected out of the plural clocks is generated and outputted to the selecting section.

(h) a mode in which the output clock information described in the above (a) to (g) is memorized beforehand in a memory section, or set by an operation circuit.

(i) a mode in which, when the clock to be outputted is switched over from one clock among the plural clocks to another clock, said one clock and said another clock are in the state of the same logic.

(j) a mode in which a plurality of delayed clocks having different phases respectively are generated by delaying the basic clock, and some one clock is selected out of the basic clock and the plural delayed clocks.

Further, as shown in Fig. 8(a), the above-mentioned usual clock has a constant period  $t_1$ , and  $t_2 = t_3$  (or the ratio of  $t_2$  to  $t_3$  is constant). On the contrary, as shown in Fig. 8(b), for the above-mentioned (2) of a dithering clock of this example of the embodiment, it is possible to make the period  $t_1$  variable ( $t_1' \neq t_1''$ ), and further, it is possible to make  $t_2' \neq t_3'$  (or to make the ratio of  $t_2'$  to  $t_3'$  (duty) variable).

#### GENERATION OF A DITHERING CLOCK:

Receiving area data (Fig. 1(5): starting area data and ending area data) from the CPU 401, the control counter 470 generates the area information (Fig. 1(6)) indicating the area where a clock is switched over to a dithering clock, and by this area information (Fig. 1(6)), the switching control section 440 gives an instruction for the generation (selection and composition) of a dithering clock to the selecting section 450.

Now, with respect to a clock having merely a different phase, because all that is required to do is to shift the above-mentioned selecting stage number information  $F_{sync}$  on

the basis of the instruction from the CPU 401, detailed explanation will be omitted.

Fig. 9 is a time chart schematically showing in a simplified manner how it is generated, the above-mentioned dithering clock (2) (generated by selecting at least two clocks having different phases respectively out of plural clocks to make composition).

In this drawing, the basic clock CLK (Fig. 9(a)), the delayed clock  $DLn-1$  as one of the plural clocks (Fig. 9(b)), the delayed clock  $DLn$  as one of the plural clocks (Fig. 9(c)), the delayed clock  $DLn+1$  as one of the plural clocks (Fig. 9(d)), and the output clock CLK' obtained by selecting and combining at least two clocks having different phases from one another out of the plural clocks (Fig. 9(e)) are shown.

In this Fig. 9, in order to make the explanation simple, the three clocks  $DLn-1$ ,  $DLn$ , and  $DLn+1$  are shown as the plural clocks. Further, by selecting the leading edge and the trailing edge from at least two clocks having different phases from one another respectively within a specified time of the clock to be outputted (the output clock) and combining the results of the selection, the output clock CLK' shown in Fig. 9(e) is generated.

As the result of this, it becomes possible to obtain the state shown in Fig. 8(b), that is, the state in which the

clock period  $t_1$  is made variable, and the duty of the clock is also made variable.

Further, in this example of the embodiment, because at least two clocks having different phases from one another are selected to compose an output clock, it is possible to control the position of the leading edges and the trailing edges of the clock arbitrarily.

In order to generate an output clock having desired rise and fall timings by selecting plural clocks as described in the above, for the shift information from the CPU 401, shift amount information (information on the interval between the selected stage numbers), number of shift times information (information on the repeating of the operation), shift mode information (information for prolonging (shortening) the period, etc. are given to the switching control section 440. In addition, the CPU 401 generates the above-mentioned sorts of shift information (output clock information) by referring to a memory portion such as a built-in or external ROM or a table.

Then, in accordance with the above-mentioned sorts of shift information, the switching control section 440 outputs the selecting stage number information (Fig. 1(7)), that is, the information on of which phase the clocks are to be selected out of the plural clocks (Fig. 1(2)), to the

selecting section 450. Then, receiving the selecting stage number information from the switching control section 440, the selecting section 450 selects clocks out of plural clocks in such a manner as to make a state in which a clock is switched over to a clock having a different phase or period from a usual one within a specified time, to output an output clock (dithering clock).

Further, in Fig. 9, regarding the selection of the plural clocks for generating a dithering clock, to state it concretely, it is done at the timing of about  $1/4$  of one period (Fig. 9(1)) and that of about  $3/4$  of one period (Fig. 9(2)) of the basic clock, in order to make the logic of the both clocks selected the same (H and H: Fig. 9(1), or L and L: Fig. 9(2)). By doing this, a noise is not produced, and a stable operation can be actualized. In the case of Fig. 9, it is shown an example in the case where plural clocks are selected at timings near the timing (1) when the logic of the both clocks is H and H. That is, this invention is characterized by it that, in switching over the output clock from one clock to another among the plural clocks by the selecting section 450, said one clock and said another clock are in the state of the same logic.

Further, in the example shown in Fig. 9, the leading edges and the trailing edges of the output clock are

determined from the three kinds of clocks; however, actually they are selected out of a number of clocks from the delay chain section 420, therefore with respect to the leading edges and the trailing edges of the output clock, it is possible to control them to come to an arbitrary position for every clock pulse.

Further, Fig. 10 is a time chart showing various kinds of states of the shift information in the case where the first synchronizing point information  $V1st = 8$ , the second synchronizing point information  $V2nd = 19$ , and the number of stages of the delay  $Vprd = 11$ .

In this drawing, it is shown how are  $Fsync$  in the case where no signal control is done (Fig. 10(d)),  $Fsync$  in the case where signal control is once carried out in the + direction (Fig. 10(e)),  $Fsync$  in the case where signal control is once carried out in the - direction (Fig. 10(f)),  $Fsync$  in the case where signal control is once carried out in the  $\pm$  direction (Fig. 10(g)),  $Fsync$  in the case where signal control is twice carried out in the + direction (Fig. 10(h)),  $Fsync$  in the case where signal control is twice carried out in the - direction (Fig. 10(i)), and  $Fsync$  in the case where signal control is once carried out in the random direction (Fig. 10(j)).

As explained in the above, by selecting at least two clocks having different phases from one another out of the plural clocks within a specified time of a clock to be outputted and combining them to output a composite clock, it is possible to vary the frequency of the output clock (dithering clock) to some extent.

In this case, as shown in Fig. 11(a), it is possible to obtain the same result as the frequency modulation by varying the frequency of the output clock in a manner such that the frequency deviation with time has a shape of a sine wave. Further, actually, to observe the frequency deviation in detail, it varies in a manner as shown in Fig. 11(b), because it is carried out by a digital circuit. In addition, an example of a sine wave is shown in this drawing, but the shape of the wave may be triangular, rectangular, or of any other arbitrary shape. For the purpose of such a control, by referring to a memory portion such as a built-in or external ROM or table, the CPU 401 generates the shift information (output clock information) for generating such a triangular wave, a rectangular wave, or a wave of an arbitrary shape as mentioned in the above.

In the above case, because a frequency deviation is produced as in the case of the frequency modulation, the frequency band of the output clock results in being

broadened. As the result of this, the spectrum of the electromagnetic radiation generated by the clock or its higher harmonics is broadened and the peak intensity of the electric field is reduced (refer to Fig. 12). Owing to this, if a clock generating device of this example of the embodiment is used in the clock generating section of various kinds of apparatus for a countermeasure against EMI, a good result can be obtained.

In addition, the above-mentioned is an example of operation of a dithering clock which has its period and frequency varied with time every moment, but with respect to a clock having a constant frequency higher than usual one (with a shorter period), it is also possible to generate it in the same procedure.

(ANOTHER EXAMPLE OF EMBODIMENT: CIRCUIT BOARD)

Further, regarding a clock generating device of this example of the embodiment and a circuit board provided with the clock generating device, the control of precision is easy because the whole is made up of a digital circuit. Further, because it is a digital circuit, it has the advantage that it is easy to handle.

Further, in the above structure, each of the components such as the basic clock generating section only, the delay chain section only, the control section only, the selecting



section only, or the CPU only may be independently arranged; however, because each part of this example of the embodiment is a digital circuit, it is possible to arrange them as an integrated circuit on one chip by combining them. In this case, by making it an integrated circuit, it has the advantage that it can actualize a small-sized circuit and becomes easy to handle. Furthermore, it is also possible to make up the chip of a device having a portion for use in common to the above-mentioned components. Further, it is possible to dispose the clock generating device of this example of the embodiment on the same circuit board together with other digital circuits.

As explained in detail in the above, according to this invention, it is possible to actualize a clock generating device, a circuit board, an image forming apparatus, and the method of generating a clock capable of controlling the phase or period of a clock pulse at an arbitrary timing.

Next, by referring to the drawings, an example of the embodiment of an image forming apparatus to attain the second object and a clock generating device of this invention will be explained in detail.

(OVERALL STRUCTURE OF A CLOCK GENERATING DEVICE)

In the following, an example of the embodiment of a clock generating device of this invention will be explained in detail.

In this Fig. 13, the CPU 401 operates as the control means for controlling the whole of a clock generating device of this invention. Further, this CPU 401 makes up means for judging which clock is to be selected within one period of the clock.

The basic clock generating section 410 generates a clock to become basic (the basic clock: Fig. 13 (1)).

The delay chain portion 420 as a clock generating portion is a group of delay elements making up the clock generating section in the claims of this invention for obtaining a plurality of delayed clocks (the plural clocks: refer to Fig. 13(2) and Fig. 2) having phases a little different from one another respectively by delaying the input signal (the basic clock from the basic clock generating section 410).

In the above, it is desirable that the delay chain portion 420 has a structure such that the delay elements are connected in cascade like a chain to make a number of stages capable of generating the delayed clocks having phases a little different from one another respectively over a time period of the two periods of the basic clock.

Further, in this embodiment, the delayed clocks are generated by using delay elements, but it is also appropriate to provide a clock generating section capable of generating a plurality of clocks having different phases respectively without using delay elements.

Further, the basic clock generating section 410 may be comprised in each of the clock generating devices, or it is also possible to distribute a basic clock to each of the clock generating devices or to each of the circuit boards from the single basic clock generating section 410.

The synchronized signal detecting section 430 is a synchronism detecting means for detecting the number of the stage (synchronizing point) of the delayed clock which is synchronized with the basic clock (the leading edge position of the desired input signal) among the plural clocks (Fig. 13(2)), and outputs the synchronization information (Fig. 13(3)). In addition, this synchronization information can be also called a phase difference state, and this synchronization information (the phase difference state) includes the synchronizing point mentioned later and the state of the phase difference itself (the phase difference state).

In the above, it is desirable that the synchronized signal detecting section 430 can output the first

synchronizing point information V1st for the one synchronized with the basic clock first, the second synchronizing point information V2nd for the one synchronized with the basic clock second, and the number of the stages of the delay element Vprd between them. In the example shown in Fig. 2, the first synchronizing point information V1st = 20, the second synchronizing point information V2nd = 50, and the number of the stages of the delay element Vprd = 30.

The switching control section 440 outputs the selecting stage number information ("selection signal" in the claims: Fig. 13(5)), that is, the information of which phase the clock is to be selected out of the plural clocks (Fig. 13(2)), in order to produce the rise and fall of the clock at desired timings (a predetermined time or a predetermined time period) on the basis of the basic clock (Fig. 13(1)) from the basic clock generating section 410, the synchronizing point information (Fig. 13(3)) from the synchronized signal detecting section 430, and the shift information ("output clock information" in the claims: Fig. 13(4)) from the CPU 401.

Incidentally, as "shift information" provided to the switching control section 440 by CPU 401, there may be - shift amount information FREQdata (information regarding an interval of select stage number),

- shift frequency information TIMESdata (information to repeat an action), and
- shift mode information MODEdata (information to increase (reduce) a cycle period).

Moreover, the structure of this switching control section 440 is made as shown in Fig. 14. That is, it is composed of the switching counter portion 441 for generating counter data through receiving the basic clock and the valid timing signals (H\_VALID and V\_VALID) and the selecting signal operating portion 442 for generating the selecting stage number information (Fsync) through receiving the above-mentioned counter data, the shift information from the CPU 401, and the synchronizing point information (V1st, V2nd, and Vprd) from the synchronized signal detecting section 430.

The selecting section 450 is a selection means which receives the selecting stage number information (Fig. 13(5)) from the switching control section 440, selects clocks so as to obtain a state in which the time intervals are dispersed, and outputs a dithering clock (Fig. 13(6)). In the above, the state in which the time intervals are dispersed is actualized by making the rise and fall of a clock occur at desired timings (a predetermined time or a predetermined time period).

In addition, in this specification, it is called "clock dithering" to obtain the same effect as the frequency modulation by varying the timings of the rise and fall or the period of the clock to be outputted. Further, a clock obtained by this clock dithering is to be called a "dithering clock".

The above-mentioned clock generating device shown in Fig. 13 is characterized by it that it selects at least two clocks having different phases from each other out of the plural clocks and combines them to output a composite clock, or it makes a judgment for the selection and composing. For the above-mentioned selection and composing, the following modes such as (a) to (j) can be thought of.

(a) a mode in which some one out of the plural clocks is selected to be outputted, and it is switched over to a different clock and outputted within one period of the clock to be outputted.

(b) a mode in which at least two clocks having different phases from one another among the plural clocks are combined and outputted as a composite clock within one period of the clock to be outputted.

(c) a mode in which, at the time of selecting and outputting some one out of the plural clocks, it is made

within one period of the clock to be outputted, a judgment which clock is to be selected.

(d) a mode in which some one is selected and outputted out of the plural clocks on the basis of a selection signal, and different clocks are selected for the leading edge and for the trailing edge within one period of the clock to be outputted.

(e) a mode in which, at the time of selecting and outputting some one out of the plural clocks on the basis of a selection signal, the selection signal is outputted to the selecting section within one period of the clock to be outputted.

(f) a mode in which, on the basis of the output clock information set beforehand, a selection signal indicating which clock is to be selected out of the plural clocks is generated and outputted to the selecting section.

(g) a mode in which, on the basis of the output clock information set beforehand and the state of phase difference detected by the synchronized signal detecting section, a selection signal indicating which clock is to be selected out of the plural clocks is generated and outputted to the selecting section.

(h) a mode in which the output clock information described in the above (a) to (g) is memorized beforehand in a memory section, or set by an operation circuit.

(i) a mode in which, when the clock to be outputted is switched over from one clock among the plural clocks to another clock, said one clock and said another clock are in the state of the same logic.

(j) a mode in which a plurality of delayed clocks having different phases respectively are generated by delaying the basic clock, and some one clock is selected out of the basic clock and the plural delayed clocks.

Further, as shown in Fig. 8(a), a clock which is generated by a conventional clock generating device has a constant period  $t_1$ , and  $t_2 = t_3$  (or the ratio of  $t_2$  to  $t_3$  is constant). On the contrary, as shown in Fig. 8(b), a clock which is generated by a clock generating device according to this example of the embodiment can be made to have a variable period  $t_1$  ( $t_1' \neq t_1$ ), and further, it is possible to make  $t_2' \neq t_3'$  (or to make the ratio of  $t_2'$  to  $t_3'$  (duty) variable).

Further, with respect to the above-mentioned selection and composition, there is a possibility not only to select clocks having different phases respectively but also to select clocks having the same phase as a result. That is, it



is a characteristic of this example of the embodiment to make a judgement in selecting clocks.

Fig. 9 is a time chart showing the operation which is a characteristic part of this example of the embodiment, that is, the operation to select at least two clocks having different phases from one another out of the plural clocks to output a composite one within one period of the clock to be outputted, schematically in a simplified way.

In this drawing, the basic clock CLK (Fig. 9(a)), the delayed clock  $DLn-1$  as one of the plural clocks (Fig. 9(b)), the delayed clock  $DLn$  as one of the plural clocks (Fig. 9(c)), the delayed clock  $DLn+1$  as one of the plural clocks (Fig. 9(d)), and the output clock CLK' obtained by selecting and combining at least two clocks having different phases from one another out of the plural clocks (Fig. 9(e)) are shown.

In this Fig. 9, in order to make the explanation simple, the three clocks  $DLn-1$ ,  $DLn$ , and  $DLn+1$  are shown as the plural clocks. Further, by selecting the leading edge and the trailing edge from at least two clocks having different phases from one another respectively within one period of the clock to be outputted (the output clock) and combining the results of the selection, the output clock CLK' shown in Fig. 9(e) is generated.

As the result of this, it becomes possible to obtain the state shown in Fig. 8(b), that is, the state in which the clock period  $t_1$  is made variable, and the duty of the clock is also made variable.

Further, in this example of the embodiment, because at least two clocks having different phases from one another are selected to compose an output clock, it is possible to control the position of the leading edges and the trailing edges of the clock arbitrarily.

In order to generate an output clock having desired rise and fall timings by selecting plural clocks as described in the above, for the shift information from the CPU 401, shift amount information (information on the interval between the selected stage numbers), number of shift times information (information on the repeating of the operation), shift mode information (information for prolonging (shortening) the period, etc. are given to the switching control section 440. In addition, the CPU 401 generates the above-mentioned sorts of shift information (output clock information) by referring to a memory portion such as a built-in or external ROM or a table.

Then, in accordance with the above-mentioned sorts of shift information, the switching control section 440 outputs the selecting stage number information (Fig. 13(5)), that is,

the information on of which phase the clocks are to be selected out of the plural clocks (Fig. 13(2)), to the selecting section 450. Then, receiving the selecting stage number information from the switching control section, the selecting section 450 selects clocks in such a manner as to make the output clock (dithering clock) have its time intervals put in a dispersed state, to output it.

Further, in Fig. 9, regarding the selection of the plural clocks for generating a dithering clock, to state it concretely, it is done at the timing of about  $1/4$  of one period (Fig. 9(1)) and that of about  $3/4$  of one period (Fig. 9(2)) of the basic clock, in order to make the logic of the both clocks selected the same (H and H: Fig. 9(1), or L and L: Fig. 9(2)). By doing this, a noise is not produced, and a stable operation can be actualized. In the case of Fig. 9, it is shown an example in the case where plural clocks are selected at timings near the timing (1) when the logic of the both clocks are H and H. That is, this invention is characterized by it that, in switching over the output clock from one clock to another among the plural clocks in the selecting section 450, said one clock and said another clock are in the state of the same logic.

Further, in the example shown in Fig. 9, the leading edges and the trailing edges of the output clock are

determined from the three kinds of clocks; however, actually they are selected out of a number of clocks from the delay chain section 420, therefore with respect to the leading edges and the trailing edges of the output clock, it is possible to control them to come to an arbitrary position for at least every clock pulse.

Further, Fig. 10 is a time chart showing various kinds of states of the shift information in the case where the first synchronizing point information  $V1st = 8$ , the second synchronizing point information  $V2nd = 19$ , and the stage number information  $Vprd = 11$ . Here, supposing that  $REVICEdata = FREQdata \times Vprd$ .

In this drawing, the following situations are shown:

- (1) Fsync (Fig. 10(d)):  $REVICEdata=0$  in the case where no signal control is done,
- (2) Fsync (Fig. 10(e)):  $REVICEdata=1$ ,  $TIMESdata=1$ ,  $MODEdata=00$  in the case where a signal control is once carried out in the + direction (frequency is lowered),
- (3) Fsync (Fig. 10(f)):  $REVICEdata=1$ ,  $TIMESdata=1$ ,  $MODEdata=11$  in the case where a signal control is once carried out in the - direction (frequency is increased),
- (4) Fsync (Fig. 10(g)):  $REVICEdata=1$ ,  $TIMESdata=1$ ,  $MODEdata=01$  in the case where a signal control is once carried out in the  $\pm$  direction (alternative direction),

- (5) Fsync (Fig. 10(h)): REVICEdata=1, TIMESdata=2, MODEdata=00 in the case where a signal control is twice carried out in the + direction (frequency is lowered),
- (6) Fsync (Fig. 10(i)): REVICEdata=1, TIMESdata=2, MODEdata=11 in the case where a signal control is twice carried out in the - direction (frequency is increased), and
- (7) Fsync (Fig. 10(j)): REVICEdata=1, TIMESdata=1, MODEdata=10 in the case where a signal control is once carried out in the random direction (irregular direction).

As explained in the above, by selecting at least two clocks having different phases from one another out of the plural clocks within one period of the clock to be outputted and combining them to output a composite clock, it is possible to vary the frequency of the output clock (dithering clock) to some extent.

In this case, as shown in Fig. 11(a), it is possible to obtain the same result as the frequency modulation by varying the frequency of the output clock in a manner such that the frequency deviation with time has a shape of a sine wave. Further, actually, to observe the frequency deviation in detail, it varies in a manner as shown in Fig. 11(b), because it is carried out by a digital circuit. In addition, an example of a sine wave is shown in this drawing, but the shape of the wave may be triangular, rectangular, or of any

other arbitrary shape. For the purpose of such a control, by referring to a memory portion such as a built-in or external ROM or a table or a calculating circuit, the CPU 401 generates the shift information (output clock information) for generating such a triangular wave, a rectangular wave, or a wave of an arbitrary shape as mentioned in the above.

In the above case, because a frequency deviation is produced as in the case of the frequency modulation, the frequency band of the output clock results in being broadened. As the result of this, the spectrum of the electromagnetic radiation generated by the clock or its higher harmonics is broadened and the peak intensity of the electric field is reduced (refer to Fig. 12). Owing to this, if a clock generating device of this example of the embodiment is used for a countermeasure against EMI, a good result can be obtained.

Incidentally, since the frequency deviation may differ depending on the above shift information and the time period during which the frequency deviation=0 may differ, the spectrum of electromagnetic emission becomes a different state. Therefore, it may be desirable that the shift information is determined in accordance with the necessity to reduce the peak of the electromagnetic emission.

Further, regarding a clock generating device of this example of the embodiment and a circuit board provided with the clock generating device, the control of precision is easy because the whole is made up of a digital circuit. Further, because it is a digital circuit, it has the advantage that it is easy to handle.

Further, in the above structure, each of the components such as the basic clock generating section only, the delay chain section only, the control section only, the selecting section only, or the CPU only may be independently arranged, but it is also possible to arrange them as an integrated circuit on one chip by combining them. In this case, by making it an integrated circuit, it has the advantage that it can actualize a small-sized circuit and becomes easy to handle. Furthermore, it is possible to make up the chip of a device having a portion for use in common to the above-mentioned components. Further, it is possible to dispose the clock generating device of this example of the embodiment on the same circuit board together with other digital circuits.

In the marketed IC to output the inputted clock as dithering clock by subjecting the inputted clock to frequency modulation with the PLL circuit, there may be a problem that normal action against discontinuous clock is not guaranteed or setting-up takes a time due to its internal feed-back

loop. However, in the present embodiment, since an entire circuit can be structured by a digital circuit, the above problems may be solved. That is, in the clock generation in the present embodiment, a normal action can be expected for discontinuous clocks and it is possible to obtain a conclusion instantly by the real-time calculation for various fluctuations.

(ANOTHER EXAMPLE OF THE EMBODIMENT: AN IMAGE FORMING APPARATUS (1))

An example of the embodiment of an image forming apparatus, to which a clock generating device of this invention is applied, will be explained. In the following, this invention will be explained on the basis of the drawings, but before this, the outline of a digital copying machine provided with an image forming apparatus and an image reading apparatus is to be explained.

Fig. 15 is a cross-sectional view showing schematically the structure of the side cross-section of a digital copying machine (hereinafter referred to as a copying apparatus simply) 1.

In this Fig. 15, the copying apparatus 1 comprises the automatic document feeder (usually called the ADF) A, the document image reading section B for reading an image of an original document fed by the automatic document feeder A, and



the image forming section (no sign attached) for forming an image read by the document image reading section B on a recording paper sheet; the document image reading section B is provided above the image forming section, and the automatic document feeder A is provided above the document image reading section B.

The image forming section comprises the writing section D for carrying out writing in accordance with read image data, the engine section E for carrying out image formation on a sheet of recording paper, the plural paper sheet containing means (hereinafter referred to as paper feed trays or simply trays) 22 and 24 such as trays containing the recording paper sheets (hereinafter referred to as the sheets) P.

The automatic document feeder A is mainly composed of the document setting base 26, the group of rollers including the roller R1, and the document conveyance processing section 28 including the switching means (no sign attached) for suitably switching over the pathway of the document etc. The document image reading section B is composed of the two mirror units 30 and 31 which is disposed under the top glass G and movable back and forth with the length of the optical path kept constant, the fixed image forming lens (hereinafter referred to as the lens simply) 33, the line-shaped image

sensor (hereinafter referred to as the CCD) 35, etc.

Although the automatic document feeder A is different in its structure from a conventional automatic document feeder, the principle itself is known publicly, and the document image reading section B is well known, therefore, the explanation of these is to be done simply.

The writing section D is composed of the laser light source (hereinafter referred to the LD also) 40, the polygonal mirror (it is a light deflector, and hereinafter referred to as the polygon also) 42, etc., and carries out image exposure based on the image data onto the image carrying member 10. The engine section E is composed of the image carrying member 10 made up of a photoreceptor drum, the charging electrode 14, the developing means 16 made up of a magnetic brush developing apparatus, the transfer electrode 18, the detaching electrode 20, the cleaning means 21, the fixing means H, etc., and is means for forming an image on a sheet. This engine section E forms a toner image on the image carrying member 10, and transfers said toner image to a sheet, to fix the toner image on the sheet; because the structure and the process are well known, its explanation is to be done simply.

In the above-mentioned structure, the process of forming a toner image on the image carrying member 10,

transferring it onto a sheet, and then ejecting the sheet on an output tray is as follows in brief.

A sheet of a document (not shown in the drawing) set on the document setting base 26 is conveyed in the document conveyance processing section 28, and during the passage under the roller R1, a slit exposure by the exposure means L is carried out. The reflected light from the document sheet is converged on the aforesaid CCD through the aforesaid mirror units 30 and 31 and the lens 33, and the image is read. The image information (image data) having been read by the document image reading section B is subjected to image processing, and is compressed, to be stored in the image memory Z3.

Then, the image data stored in the image memory Z3 is read out in response to image formation, and is expanded; the LD 40 in the writing section D is driven in accordance with said image data, to make an exposure on the image carrying member 10. Before this exposure, the image carrying member rotating in the direction of the arrow mark (counter-clock direction) is charged to a specified electric potential by the corona discharging action of the charging electrode 14, and the electric potential of the exposed area is reduced in accordance with the exposure amount, resulting in the formation of an electrostatic latent image on the image

carrying member 10 in accordance with the image data. The electrostatic latent image is reversely developed by the aforesaid developing means 16, to become a visible image (a toner image).

On the other hand, before the leading edge portion of the toner image on the image carrying member 10 reaches the transfer zone, a sheet P, for example in the paper feed tray 22, is conveyed to reach the registration rollers R10, by which its leading edge is regulated. The sheet P is conveyed to the transfer zone by the registration rollers R10, which start rotating in synchronism with the toner image formed on the image carrying member 10, in order that it may come to be superposed on the toner image, that is, the area of the toner image formed on the image carrying member 10. In the transfer zone, the toner image on the image carrying member 10 is transferred onto the sheet P by the actuation of the transfer electrode, and then said sheet P is detached from the image carrying member 10 by the actuation of the detaching electrode 20.

After that, by the application of the pressure and heat by the fixing means H, the toner particles forming the aforesaid toner image are fused and fixed on the sheet P, which is then ejected onto the output tray T through the

ejection path 78 and the ejection rollers 79 as an ejection means.

In addition, in Fig. 15, the sheet P is shown in the paper feed tray 22 only.

In this drawing, the reference sign S in the paper feed tray 24 is a movable plate, the free end of which is always urged upward by an urging means such as a coil spring (not shown in the drawing); as the result of this, the topmost sheet is brought into contact with the conveying-out roller to be described later. In addition, the paper feed tray 22 also has the same structure as that described in the above. The paper feed trays 22 and 24 are paper containing feed means which contain sheets, and in the embodiment, they are arranged vertically in two stages; however, more number of paper feed trays can also be provided.

Between this paper feed tray 24 and the bottom wall of the apparatus mainframe, the space portion 25 with a specified spacing is formed. This space portion 25 is used in the mode in which an image is formed on each of both sides of a sheet P, and is a part of the second conveyance path 80 (to be described later) for reversing a sheet upside down, to make up the reversing path for reversing a sheet upside down.

Above the front end portion (the portion corresponding to the leading edge of a sheet P contained with respect to

the paper feeding direction) of each of the paper feed trays 22 and 24, there are provided the conveying-out rollers 50 and 53, the feed rollers 51 and 54, which are located at the downstream side of the conveying-out rollers 50 and 53 respectively, and the double-feed preventing rollers 52 and 55 pressed to the feed rollers 51 and 54 respectively for preventing the multiple-feed of the sheets P; these are paper feeding means for conveying out a single sheet separately from other sheets contained in the paper feed tray 22 and 24 one by one.

60 denotes the manual feed tray as an outside-located sheet containing means, at least a part of which is projected out of the image forming apparatus mainframe, for setting sheets, and has such a structure as to be capable of opening and closing with its lower end made as a supporting point against the side wall of the image forming apparatus mainframe. In order to feed out a sheet P set on the manual feed tray 60 to accompany image formation, the conveying-out roller 61, the feed roller 63 located at the downstream side of the conveying-out roller 61, and the double-feed preventing roller 65 for preventing multiple-feed of the sheets P compose the outside paper feeding means having substantially the same structure to perform the same function as the paper feeding means which are provided corresponding

to the above-mentioned paper feed trays 22 and 24 respectively.

For the pathway of a sheet, the image formation path 70 (extending from the lower part to the upper part with respect to the moving direction of the sheet) for making the sheet P be subjected to image formation (image recording) on it, the upper sheet conveyance path 72 for conveying the sheets contained in the upper paper feed tray 22, the lower sheet conveyance path 74 for conveying the sheets contained in the lower paper feed tray 24, and the sheet ejection path 78 for ejecting the sheet having been subjected to image formation onto the output tray T are provided. That is, a sheet can be conveyed from each of the paper feed trays 22 and 24 through the image forming means E to the ejection rollers 79. This conveyance path to convey a sheet is called the first conveyance path in this specification. In addition, this first conveyance path is the conveyance path in which a sheet is conveyed in the case where an image is formed on the one side of the sheet.

The (upper) bifurcating guide 90 is controlled in such a manner as to let a sheet P having an image formed on its first side or a sheet P having images on its both sides respectively proceed to the sheet ejection path 78 or to the second conveyance path 80 to be described later. In other

words, it is controlled in accordance with the mode of the image formation set by a user (a mode in which an image is formed on the one side of a sheet only, or a mode in which images are formed on the both sides of a sheet respectively), and is a switching means for switching over the pathway of the sheet P being conveyed upward in Fig. 15 in the image formation path 70 to the sheet ejection path 78 or to the second conveyance path. To state it concretely, in the case where the mode in which image formation on both sides of a sheet is to be carried out has been set, the bifurcating guide 90 is controlled to come to the position indicated by the broken line in the drawing through a control section (not shown in the drawing) in order that the sheet P, which has been subjected to image formation for its first side to have a toner image transferred, may be fed into the second conveyance path 80. Further, in the case where the mode in which image formation on one side of a sheet is to be carried out is set, or in the case where the mode in which image formation on both sides of a sheet is to be carried out has been set, and a sheet having an image on each of its both sides formed already is to be conveyed, the bifurcating guide 90 is controlled to come to the position shown by the solid line in the drawing through the control section (not shown in the drawing).



Further, the image forming apparatus comprises the second conveyance path 80 in order to make it possible to form an image again on the sheet on one side of which an image has already been formed. The image forming process for the second side of a sheet is as follows.

As described in the above, when a sheet P having been subjected to image formation for the first side moves upward in the first conveyance path (the image formation path 70) and its leading edge reaches the bifurcating guide 90, because said bifurcating guide 90 is kept at the position shown by the broken line in the drawing, the sheet P enters the second conveyance path 80, to continue to move. The entrance portion of the second conveyance path 80 has a shape of a gentle circular arc, which secures smooth moving of the sheet P. Then, the sheet P, having made a U-turn as drawing a circular arc at the entrance portion of the second conveyance path 80, moves down in the second conveyance path toward the reversing path, is gripped by the reversing rollers R20, and is conveyed out toward the bifurcating guide 93. At this time, because the bifurcating guide 93 is at the position shown by the solid line in the drawing, said sheet P being conveyed out is guided to the aforesaid space portion 25 formed under the lower paper feed tray 24. The first side

with an image formed of this sheet P, which has been guided to this space portion 25, faces down.

Then, the reversing rollers R20 stop rotating with the trailing edge of the sheet P gripped between them, and after that, when they start rotating in the direction reverse to the above-mentioned, the sheet P is conveyed into the first conveyance path (through the lower conveyance path 74 to the image formation path 70, as kept reversed upside down, that is, with its second side having no image formed made to face the image carrying member 10, and its leading edge is regulated by the registration rollers R10.

On the other hand, on the image carrying member 10, the second toner image has already been formed by the above-mentioned process, and when the registration rollers R10 start rotating in synchronism with the rotation of said image carrying member 10, the sheet P enters the transfer zone as kept in the state of being superposed on the second toner image area. Then, after it is subjected to transfer processing, detaching processing, and fixing processing, when the leading edge of the sheet P having an image for the rear side formed reaches the portion at which the bifurcating guide 90 is located, the bifurcating guide 90 is kept at the position shown by the solid line in the drawing, which brings the image formation path 70 into the state of leading to the

sheet ejection path 78 and breaks the leading to the second conveyance path 80; therefore, the sheet P enters the sheet ejection path 78, and is ejected onto the output tray T through the ejection rollers 79.

Incidentally, regarding the manual feed tray 60 provided at the manual feeding section, in this embodiment, as shown in Fig. 13, it is provided on the opening-closing door 100 the outside surface of which makes the side wall of the apparatus mainframe. Further, including the manual feed tray 60, the paper feeding means for conveying out the sheets set on the manual feed tray 60 is mounted to the opening-closing door at approximately the same height position as the paper feeding devices for the paper feed tray 22.

The conveyance path 66 for the sheet P which is conveyed into the apparatus from on the manual paper feed tray 60 (hereinafter referred to as the third conveyance path) has such a structure as to extend across the aforesaid second conveyance path 80 to lead to the first conveyance path.

To state it concretely, it has such a structure as to have its end at the point before the image recording portion, in which the transfer electrode 18 is located, that is, at the upstream side of it with respect to the sheet conveying direction in the image formation path 70, and to state it

more concretely, at the junction point 76 before (at the upstream side of) said registration rollers R10.

Fig. 16 is a block diagram showing the control system of the copying machine 1.

As described in the foregoing, the automatic document feeder A is an apparatus carrying out conveyance of a document, and for its control system, it comprises the ADF control circuit A1 as a control circuit for controlling the driving of the automatic document feeder A, and the oscillator A5 for generating a clock. This oscillator A5 is a circuit for generating a usual clock. Further, the ADF control circuit A1 is a circuit for controlling the driving of the document conveyance processing section 28 including a group of rollers, switching means, etc., a sensor (not shown in the drawing) for carrying out the size detection of the document, etc., and may be made up of a gate array only, or may comprise a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This ADF control circuit A1 is driven by a clock which is generated by the oscillator A5. Further, the automatic document feeder A carries out the giving and receiving of data with the image processing and engine control board (hereinafter referred to as the engine control board) C, and the control of document conveyance is carried out as being controlled by the engine control board C.

As described in the above, the document image reading section B is a section for photoelectrically converting an image of a document, and for its control system, it comprises the reading mechanism control circuit B1 as a control circuit for controlling the driving of the mechanism of the document image reading section B, the oscillator B5 for generating a clock, and the CCD control circuit B2 as a photoelectric conversion control circuit for controlling the CCD 35 as a photoelectric conversion portion. This clock generating device B5 is a circuit for carrying out the generation of a usual clock like the above-mentioned oscillator A5. Further, the reading mechanism control circuit B1 is a circuit for controlling the driving of the mechanical system of the document image reading section B such as the movement of the aforesaid two mirror units 30 and 31 and the movement of the lens 33 in accordance with the enlargement and reduction; it may be made up of a gate array only, or it may comprise a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This reading mechanism control circuit B1 is driven by a clock generated by the clock generating device B5.

Further, the CCD control circuit B2 is a control circuit for driving the CCD 35. This CCD driving circuit B2 is driven not by a clock from the clock generating device B5, but by a dithering clock from the clock generating device CR6

as described later. Further, the document image reading section B carries out the giving and receiving of data with the engine control board C to be described later, and carries out the control as being controlled by the engine control board C.

As described in the above, the writing section D is a section for carrying out writing in accordance with image data; for its control system, it comprises the writing control circuit D1 for controlling the modulation of the light emitted by the LD 40 on the basis of the image data, and the detector (index sensor) D2 for detecting the light emitted by the LD 40 and deflected by the polygon 42 as a deflector to output an index signal. In the above, the detector D2 outputs an index signal by detecting the light of the LD 40 for each of main scanning lines arranged in the sub-scanning direction (the moving direction of the image carrying member 10), and the writing in the main scanning direction is started on the basis of this index signal; because this structure itself is known to the public, the explanation is omitted in this specification. The writing control circuit D1 is a circuit for carrying out the control of the intensity modulation and/or the pulse width modulation of the LD 40 based on the image data, and may be made up of a gate array only, or it may comprise a CPU as well as a ROM, a

RAM, etc. in addition to a gate array. This writing control circuit D1 is driven by a clock generated by the oscillator CW1 to be described later. Further, the writing section D carries out the giving and receiving of data with the engine section E and the engine control board C to be described later, and carries out the exposure (writing) based on the image data as being controlled by the engine section E and the engine control board C.

As described in the above, the engine section E is a section for forming an image on a sheet, and for the control system, it comprises the control circuit E1 and the oscillator E5 for generating a clock. This clock generating device E5 is a circuit for carrying out the generation of a usual clock like the above-mentioned oscillator A5. Further, the engine control circuit E1 is a circuit for controlling the driving of the above-mentioned image carrying member 10, the charging electrode 14, the developing means 16, the transfer electrode 18, the detaching electrode 20, the fixing means H, etc., and it may be made up of a gate array only, or it may comprise a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This engine control circuit E1 is driven by a clock generated by the clock generating device E5. The engine section E carries out the giving and receiving with the engine control board C to be described

later, and carries out the control as being controlled by the engine control board C.

The operation section U is a section for carrying out the setting of the state of the operation of the copying machine or the operation by a user in the operation panel provided at the front side of the copying machine 1 (a panel provided with a display portion such as a liquid crystal and an input portion such as a touch panel or keys), and for the control system, it comprises the operation control circuit U1 for carrying out the control of the display of the operation panel and the detection of the pressing of the touch panel or the keys, and the oscillator U5 for generating a clock. This oscillator U5 is a circuit for generating a usual clock like the above-mentioned oscillator A5. Further, the operation control circuit U1 is a circuit for making the control such as the control of the display on the liquid crystal and the detection of the pressing of the touch panel or the keys, and it may be made up of a gate array only, but because of the large number of the characters to be displayed, it is desirable that it comprises a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This operation control circuit U1 is driven by a clock generated by the clock generating device U5. The operation section U carries out the giving and receiving of data with the overall control



board Z to be described later, and carries out the control as being controlled by the overall control board Z, while it transmits the information set by a user to the overall control board Z.

The interface section (hereinafter referred to as the I/F section) V is a interface section for carrying out the communication (giving and receiving of data) with an external apparatus (for example, it is an external apparatus such as a FAX machine or a print controller, and in this case, it may be one built in the copying machine 1.), and for the control system, it comprises the I/F control circuit V1 for carrying out the control of the interface with the external apparatus, and the oscillator V5 for generating a clock. This oscillator V5 is a circuit for carrying out the generation of a usual clock like the above-mentioned oscillator A5. Further, the I/F control circuit V1 is a circuit for carrying out the control of the interface, and it may be made up of a gate array only, or it may comprise a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This I/F control circuit V1 is driven by a usual clock generated by the oscillator V5. The I/F section carries out the giving and receiving of data with the overall control board Z to be described later, and carries out the control as being controlled by the overall control board Z, while it transmits

the information from an external apparatus to the overall control board Z.

The engine control board C is a circuit board for controlling the automatic document feeder A, the document image reading section B, the writing section D, the engine section E, etc., while carrying out the control of the sheet conveyance and image processing, and it comprises the CPU C1 for managing the control of these controls, the oscillator C5 for generating a clock, the reading control portion CR for carrying out the image processing of read image data etc., and the writing control portion CW for carrying out the image processing of image data to be written. This oscillator C5 is a circuit for generating a usual clock like the above-mentioned oscillator A5. Further, the CPU C1 functions as a control circuit for carrying out various kinds of controls on the basis of a program stored in a ROM (not shown in the drawing), using a RAM (not shown in the drawing) as an operation area. This CPU C1 is driven by a clock generated by the oscillator C5. In addition, this engine control board C has such a structure as to carry out the giving and receiving of data with the automatic document feeder A, the document image reading section B, the writing section D, the engine section E, and the overall control board Z to be described later, and controls the automatic document feeder

A, the document image reading section B, the writing section D, and the engine section E under the control by the overall control board Z.

The reading control portion CR is a portion for giving a clock for controlling the CCD control circuit B1, while carrying out the image processing of the image data obtained by the photoelectric conversion by the CCD 35, and constitutes a part of the image reading apparatus together with the document image reading section B. This reading control portion CR comprises the read image processing circuit CR1 for carrying out the image processing of image data and the clock generating device CR6 for generating a dithering clock. The read image processing circuit CR1 is a circuit for applying the image processing such as area discrimination, brightness/density conversion, filter, re-sizing, gamma transformation, error diffusion, and smoothing to the image data read by the CCD 35, and it may be made up of a gate array only, or it may comprise a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This clock generating device CR6 is a circuit for carrying out the generation of a dithering clock.

The clock generating device described in the above is one that selects desired clocks out of the plural clocks so as to bring the time intervals into a dispersed state to

output a dithering clock. This dithering clock is one that has its frequency modulated at specified intervals of the period  $T$  on the basis of a specified modulation profile such as shown in Fig. 17. Further, the width of this frequency deviation (that is, the band width), the modulation width (the width in the left-to-right direction in Fig. 12, or the width up-to-down direction in Fig. 17) is within  $\pm 10\%$  (or desirably within  $\pm 5\%$ , further more desirably within  $\pm 2\%$ ) of the central frequency of the diffused dithering clock (the frequency  $N_r$ , in the case where the frequency deviation is produced with the frequency of the basic clock signal  $N_r$  made the center) (the solid line in Fig. 17).

Further, the modulation is not necessarily done by making the frequency of the basic clock signal be the central frequency in the modulation width, but it is appropriate to make the frequency of the basic signal be the maximum frequency in the modulation width (the single dot and dash line in Fig. 17), or on the contrary, it is appropriate to make it be the minimum frequency in the modulation width (the broken line in Fig. 17).

Further, it is appropriate to make the modulation profile a sine wave or the like, however, it is desirable to use a modulation profile such as shown in Fig. 17 for the purpose of reducing the peak of EMI component, because the

clock is kept at a constant frequency for a short time to make it possible to diffuse the spectrum uniformly.

Further, this dithering clock is inputted to the read image processing circuit CR1 as the driving clock for the read image processing circuit CR1, which is driven by this dithering clock. Furthermore, this dithering clock is also inputted to the CCD control circuit B1 as the driving clock for the CCD control circuit B1, which is driven by the dithering clock. In addition, the image data which has been subjected to image processing in the read image processing circuit CR1 is directly outputted to the recording image processing circuit CW1, or is stored in the image memory Z3 through the compression-expansion circuit Z2.

The writing control portion CW is a portion which gives a clock signal for controlling the writing control circuit D1, while carrying out the image processing of image data. This writing control portion CW comprises the writing image processing circuit CW1 for carrying out the image processing of image data and the oscillator CW5 for generating a clock. The writing image processing circuit CW1 is a circuit for applying image processing adjusted to the characteristics of the writing section D and the engine section E to the image data, which have been read from the image memory Z3 and expanded, and outputting the data to the LD40, and it is made

up of a gate array only, but it may comprise a CPU as well as a ROM, a RAM, etc. in addition to a gate array. This oscillator CW5 is a circuit for carrying out the generation of a usual clock like the above-mentioned oscillator A5. This clock is inputted to the writing image processing circuit CW1 as the driving clock for the writing image processing circuit CW1, which is driven by this clock. Moreover, this clock is inputted also to the writing control circuit D1 as the driving clock for the writing control circuit D1, which drives the LD 40, applying to it the modulation in accordance with the image data outputted from the writing image processing circuit CW1 by the clock.

The overall control board Z is a circuit board for managing the control of the whole copying machine, that is, a circuit board for carrying out the control of the sequence of the whole copying machine. This overall control board Z comprises the CPU Z1 as a control circuit for carrying out the sequence control of the whole copying machine, the compression and expansion circuit Z2 for compressing/expanding image data, the image memory Z3 for storing image data, and the clock generating device Z6 for generating a dithering clock.

This clock generating device Z6 is the same as the above-mentioned clock generating device CR6, therefore, its

explanation is to be omitted. Further, the CPU Z1 functions as the sequence control circuit for carrying out the sequence control of the whole copying machine on the basis of a program stored in a ROM (not shown in the drawing), using a RAM (not shown in the drawing) as a working area. This CPU Z1 is driven by the dithering clock generated by the clock generating device Z6. The compression and expansion circuit Z2 is a gate array composed of the compressing circuit for compressing the image data read by the CCD 35 (the image data having been subjected to the image processing by the read image processing circuit CR1), and the expansion circuit for expanding the image data (compressed data) stored in the image memory Z3 to output the data to the recording image processing circuit CW1. Further, the image memory Z3 is a memory means for memorizing the image data compressed by the compression and expansion circuit Z2. These compression and expansion circuit Z2 and the image memory Z3 are driven by the dithering clock generated by the clock generating device Z6. In addition, this overall control board Z has such a structure as to carry out the giving and receiving of data with the operation section U, the I/F section V, and the engine control board C, to control the whole copying machine.

As explained in the above, in an image forming apparatus of this embodiment, the CCD control circuit B1 and

the read image processing circuit CR1 are driven by the same dithering clock. This is because, if the CCD control circuit B1 and the read image processing circuit CR1 were driven by different dithering clocks respectively, the matching between the image data outputted from the CCD 35 and the image data to be subjected to the image processing could not be obtained, which would make a satisfactory image reading impossible. In addition, because this read image processing circuit CR1 performs image processing in real time during the reading by the CCD 35 in this embodiment, it can solve this problem particularly.

Further, this embodiment has a structure such that at least one control circuit (in this embodiment, the CCD control circuit B1 and the read image processing circuit CR1) is driven by a dithering clock, while the writing control circuit D1 is driven by a usual clock. This is because the writing system generally requires a high precision, and for that reason, in the case where a dithering clock is used in a usual manner, unevenness is easy to appear in writing owing to the variation of the phase of the clock, which makes it difficult to obtain a good image recording.

Further, in this embodiment, because a dithering clock is used, it is possible to reduce the intensity of the peak portion of the fundamental wave and higher harmonics of the



radiation, and the countermeasure against EMI can be sufficiently taken.

(IMAGE FORMING APPARATUS (2))

Fig. 18 is a block diagram showing the control system of the copying machine 1 in another example of the embodiment. In addition, in this example of the embodiment, the same signs are attached to the members which have basically the same structure as those in the above-mentioned example of the embodiment; in the following, they are the same as the above-mentioned example so long as a particular explanation is not given, and the explanation will be omitted.

In the above-mentioned embodiment, the two clock generating devices CR6 and Z6 are utilized, and the control circuits which are driven by the dithering clock are the CCD control circuit B2, the read image processing circuit CR1, the CPU Z1, the compression and expansion circuit Z2, and the image memory Z3 among the plural control circuits.

However, as shown in Fig. 18, this embodiment has a structure such that a dithering clock is outputted from each of the clock generating devices A6, B6, E6, U6, V6, C6, CR6, CW6, and Z6. In this way, by providing a clock generating device for generating a dithering clock in every portion, every control circuit is made to be driven by a dithering

clock. Owing to this, a better countermeasure against EMI can be taken.

Incidentally, in the case where a clock generating device is provided in every portion in a simple way, various problems such that a good image recording can not be obtained, that a good image reading can not be made, and further, that matching among the various control circuits can not be obtained are produced.

Therefore, in this embodiment, assuming that the frequency deviation of the dithering clocks generated by the respective clock generating devices A6, B6, E6, U6, V6, C6, CR6, CW6, and Z6 are WA, WB, WE, WU, WV, WC, WCR, WCW, and WZ, by making the frequency deviation satisfy any one of the following inequalities, it has become possible to solve the above-mentioned problem.

$$WV < WCW < WCR < WA,$$

$$WV < WCW < WCR < WB,$$

$$WV < WCW < WCR < WE,$$

$$WV < WCW < WCR < WU,$$

$$WV < WCW < WCR < WC, \text{ and}$$

$$WV < WCW < WCR < WZ.$$

That is, by making it the narrowest of all, the frequency deviation WV of the dithering clock for driving the I/F control circuit V1 which carries out the communication

with an external apparatus, the occurrence of an error in the communication with the external apparatus can be suppressed, which makes it possible to secure matching with the external apparatus.

Further, by making the frequency deviation WCW of the dithering clock for driving the writing control circuit D1 which carries out writing control broader than the frequency deviation WV and narrower than the other frequency deviations (WCR, WA, WB, WE, WU, WC, and WZ), it is possible to suppress the unevenness of writing owing to the diffusion, to obtain a good image recording. Further, the frequency deviation WCR of the dithering clock for driving the CCD control circuit B2 is made broader than the frequency deviations WV and WCW and narrower than the other frequency deviations (WA, WB, WE, WU, WC, and WZ). This is based on the following reasons. That is, according to the result of the study carried out by the inventors, in the reading system, the influence of the dithering clock to the image signal appears as the variation of the storage time in reading a line of an image by the CCD 35, and the image data for each pixel are scarcely influenced by it. Further, as compared to the storage time for one line, the variation of the frequency deviation of a clock is negligibly small. On the contrary, in the writing system, the influence of the dithering clock to the image signal

appears at the printing position of each pixel, and the variation of the printing position of each pixel makes a jitter, to result in lowering the image quality.

Further, this embodiment has a structure such that the output of the index signal by the detector (the index sensor) D2 is inputted also to the clock generating device CW6. The clock generating device CW6 has a structure such that resetting can be made when this index signal is inputted. That is, as described in the above, on the basis of the modulation profile, the clock generating device CW6 makes the frequency band of the basic clock signal diffuse by bringing it into the same state as that in which its frequency is modulated at specified intervals of the period  $T$ ; however, because resetting is made in response to the index signal, diffusion can be made always to take the same way in each of the lines of main scanning, which makes it possible to carry out a good image writing. Especially, in this case, because the way of diffusion is known beforehand by the modulation profile, by applying image processing (image processing by the recording image processing circuit CW1) in accordance with this, a better image writing can be carried out.

Further, this embodiment has a structure such that a reset is applied to the clock generating device CW6 in response to the index signal; the moire, which becomes a

problem in writing if the writing control circuit D1 is driven by a dithering clock without applying this reset, can be prevented by the diffusion of the dithering clock. In this case, it is necessary only to make the integral multiple of the period T of the modulation profile not equivalent to the time for scanning one line of the main scanning.

(IMAGE FORMING APPARATUS (3))

Further, as in this embodiment, in the case where a plurality of clock generating devices are used, and the frequency deviations of the dithering clocks generated by those are different from one another, a transmission error is produced in carrying out the giving and receiving of information between the control circuits. Therefore, as shown in Fig. 19, it is desirable to provide a temporary memory (such as a buffer memory) for memorizing data to be communicated on the midway of the communication line for carrying out the data communication between the control circuits. Owing to this, the giving and receiving of data can be carried out regardless of the difference in the frequency deviation, the occurrence of a transmission error can be prevented, and matching among the various control circuits can be easily made.

Further, as in this embodiment, in the case where a plurality of clock generating devices are provided in one

apparatus, it happens sometimes a situation where it is desirable to make the timings of the various control circuits common to all. For that purpose, it is desirable to bring the plural clock generating devices in a synchronized condition. For the way of this synchronization, for example, it can be done by giving a reset signal to the above-mentioned plural clock generating devices which are desired to be put in synchronism with one another. In this case, it is not necessary to apply resetting to all of the plural clock generating devices, but it is necessary only to apply resetting at least to the clock generating devices which are desired to be brought in synchronism.

As described in detail in the above, according to an image forming apparatus to which a clock generating device of this invention is applied, it becomes possible that while a good image recording and image reading are carried out, matching among various control circuits is made, and a countermeasure against EMI is sufficiently taken.

As described in detail in the above, according to this invention, a clock generating device, a circuit board, an image forming apparatus, and the method of generating a clock capable of, with respect to the leading edge or the trailing edge of a clock, controlling it to come to an arbitrary position for every clock can be actualized.